CLAIMS

1. A method for formation of polyetherols comprising the steps of:

a) providing at least one alkylene oxide;

b) providing at least one initiator molecule having at least one alkylene oxide reactive hydrogen; and

c) reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of an aluminum phosphonate catalyst to form a polyetherol.

2. The method of Claim 1, wherein step a) comprises providing ethylene oxide, propylene oxide, butylene oxide, epichlorohydrin or mixtures of these alkylene oxides.

3. The method of Claim 1, wherein step b) comprises providing as the at least one initiator molecule, an alcohol, a polyhydroxyl compound, a mixed hydroxyl and amine compound, a polyamine compound, or mixtures of these initiator molecules.

4. The method of Claim 3, wherein step b) comprises the further step of pre-reacting the initiator molecule with at least one alkylene oxide to form an oligomer and then using the oligomer as the initiator molecule in step c).

5. The method of Claim 4, comprising forming an oligomer having a number average molecular weight of from 200 to 1500 Daltons.

6. The method of Claim 1, wherein step c) comprises providing the aluminum phosphonate catalyst in an amount of from 0.1 to 5.0 weight percent based on the total weight of the polyetherol.

7. The method of Claim 1, wherein step c) comprises providing as the aluminum phosphonate catalyst an aluminum phosphonate having the general structure of $RPO-(OAlR'R'')_2$ wherein: O represents oxygen; P represents pentavalent phosphorous; Al represents aluminum; R comprises a hydrogen, a methyl group, an alkyl group, or an aryl group; and R' and R" independently comprise a halide, an alkyl group, an alkoxy group, an aryl group, or an aryloxy group.

8. The method of Claim 7, comprising providing as the aluminum phosphonate catalyst an aluminum phosphonate wherein: R is a methyl group; and R' and R" independently comprise one of an ethyl group, an ethoxy group, a propyl group, a propoxy group, a butyl group, a butoxy group, a phenyl group, or a phenoxy group.

9. The method of Claim 1, wherein step c) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst to form a polyetherol having an unsaturation of less than or equal to 0.020 meq/g KOH

10. The method of Claim 1, wherein step c) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum

phosphonate catalyst to form a polyetherol having an unsaturation of less than or equal to 0.015 meq g KOH.

11. The method as recited in Claim 1, wherein step c) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst for a period of time from 15 minutes to 15 hours.

12. The method as recited in Claim 1, wherein step c) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst for a period of time sufficient to produce a polyetherol having a number average molecular weight of from 1500 to 8000 Daltons.

13. The method as recited in Claim 1, wherein step c) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst at a temperature of from 95° to 150°C.

14. The method as recited in Claim 1, wherein step c) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst at a temperature of from 105° to 130°C.

15. A method for formation of polyetherols comprising the steps of:

a) providing at least one alkylene oxide;

b) providing at least one initiator molecule having at least two alkylene oxide reactive hydrogens;

c) providing an aluminum phosphonate catalyst having the general structure of $RPO\text{-}(OAlR'R'')_2$ wherein: O represents oxygen; P represents pentavalent phosphorous; Al represents aluminum; R comprises a hydrogen, a methyl group, an alkyl group, or an aryl group; and R' and R'' independently comprise a halide, an alkyl group, an alkoxy group, an aryl group, or an aryloxy group; and

d) reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst to form a polyetherol.

16. The method of Claim 15, wherein step a) comprises providing ethylene oxide, propylene oxide, butylene oxide, epichlorohydrin or mixtures of these alkylene oxides.

17. The method of Claim 15, wherein step b) comprises providing as the at least one initiator molecule a polyhydroxyl compound, a mixed hydroxyl and amine compound, a polyamine compound, or mixtures of these initiator molecules.

18. The method of Claim 15, wherein step b) comprises the further step of pre-reacting the initiator molecule with at least one alkylene oxide to form an oligomer and then using the oligomer as the initiator molecule in step d).

19. The method of Claim 18, comprising forming an oligomer having a number average molecular weight of from 200 to 1500 Daltons.

20. The method of Claim 15, wherein step c) comprises providing the aluminum phosphonate catalyst in an amount of from 0.1 to 5.0 weight percent based on the total weight of the polyetherol.

21. The method of Claim 15, wherein step c) comprises providing as the aluminum phosphonate catalyst an aluminum phosphonate wherein: R is a methyl group; and R' and R" independently comprise one of an ethyl group, an ethoxy group, a propyl group, a propoxy group, a butyl group, a butoxy group, a phenyl group, or a phenoxy group.

22. The method of Claim 15, wherein step d) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst to form a polyetherol having an unsaturation of less than or equal to 0.020 meq/g KOH

23. The method of Claim 15, wherein step d) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst to form a polyetherol having an unsaturation of less than or equal to 0.015 meq/g KOH.

24. The method as recited in Claim 15, wherein step d) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst for a period of time from 15 minutes to 15 hours.

25. The method as recited in Claim 15, wherein step d) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst for a period of time sufficient to produce a polyetherol having a number average molecular weight of from 1500 to 8000 Daltons.

26. The method as recited in Claim 15, wherein step d) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst at a temperature of from 95° to 150°C.

27. The method as recited in Claim 15, wherein step d) comprises reacting the at least one alkylene oxide with the at least one initiator molecule in the presence of the aluminum phosphonate catalyst at a temperature of from 105° to 130°C.

28. A method for formation of polyetherols comprising the steps of:

a) providing propylene oxide;

b) providing at least one initiator molecule having at least one propylene oxide reactive hydrogen; and

c) reacting the propylene oxide with the at least one initiator molecule in the presence of an aluminum phosphonate catalyst to form a polyetherol.

29.) The method of Claim 28 comprising the further step of reacting the polyetherol formed in step c) with ethylene oxide in the presence of an aluminum phosphonate catalyst to thereby form terminal caps of ethylene oxide.

30.) The method of Claim 29 comprising forming the terminal caps of ethylene oxide in an amount of from 5 to 80% by weight based on the total weight of the polyetherol.

31.) The method of Claim 28 wherein step b) comprises providing at least one diol initiator molecule having at least two propylene oxide reactive hydrogens.

32.) A method for formation of heteric polyetherols comprising the steps of:

a) providing a mixture of alkylene oxides;

b) providing at least one initiator molecule having at least one alkylene oxide reactive hydrogen; and

c) reacting the mixture of alkylene oxides with the at least one initiator molecule in the presence of an aluminum phosphonate catalyst to form a heteric polyetherol.

33.) The method of Claim 32 comprising the further step of reacting the heteric polyetherol formed in step c) with ethylene oxide in the presence of an aluminum phosphonate catalyst to thereby form terminal caps of ethylene oxide.

34.) The method of Claim 33 comprising forming the terminal caps of ethylene oxide in an amount of from 5 to 20% by weight based on the total weight of the polyetherol.

35.) The method of Claim 32 comprising the further step of reacting the heteric polyetherol formed in step c) with propylene oxide in the presence of an aluminum phosphonate catalyst to thereby form terminal caps of propylene oxide.

36.) The method of Claim 35 comprising forming the terminal caps of propylene oxide in an amount of from 5 to 15% by weight based on the total weight of the polyetherol.

37. A method for formation of polyetherols comprising the steps of:

a) providing ethylene oxide;

b) providing at least one initiator molecule having at least one ethylene oxide reactive hydrogen; and

c) reacting the ethylene oxide with the at least one initiator molecule in the presence of an aluminum phosphonate catalyst to form a polyetherol.

38.) The method of Claim 37 comprising the further step of reacting the polyetherol formed in step c) with propylene oxide in the presence of an aluminum phosphonate catalyst to thereby form terminal caps of propylene oxide.

39.) The method of Claim 38 comprising forming the terminal caps of propylene oxide in an amount of from 5 to 80% by weight based on the total weight of the polyetherol.

40. A method for formation of polyetherols comprising the steps of:

a) providing at least one alkylene oxide;

b) providing at least one oligomer having at least one alkylene oxide reactive hydrogen; and

c) reacting the at least one alkylene oxide with the at least one oligomer in the presence of an aluminum phosphonate catalyst to form a polyetherol.

41.) The method of Claim 40 comprising providing at least one oligomer having a number average molecular weight of from 200 to 1500 Daltons.

42. A method for terminal cap modification of polyetherols comprising the steps of:

a) providing a polyetherol; and

c) reacting the polyetherol with at least one alkylene oxide in the presence of an aluminum phosphonate catalyst to form a modified polyetherol having terminal caps comprising the alkylene oxide.

43.) The method of Claim 42 comprising reacting the polyetherol with ethylene oxide, propylene oxide, epichlorohydrin, or mixtures of these alkylene oxides to form the modified polyetherol.

44.) The method of Claim 42 comprising providing a polyetherol having a number average molecular weight of from 500 to 10,000 Daltons in step a).

45. A method for formation of linear block copolymer polyetherols comprising the steps of:

a) providing a first alkylene oxide;

b) providing at least one diol initiator molecule having two alkylene oxide reactive hydrogens; and

c) reacting the first alkylene oxide with the at least one diol initiator molecule in the presence of an aluminum phosphonate catalyst to form a linear polyetherol; and

d) reacting the reaction product of step c) with a second alkylene oxide other than the first alkylene oxide in the presence of the aluminum phosphonate catalyst to form a linear block copolymer polyetherol.

46. The method of claim 45, wherein the first alkylene oxide is one of propylene oxide or ethylene oxide and the second alkylene oxide is the other of propylene oxide or ethylene oxide.

47. The method of claim 45, wherein the first alkylene oxide is one of propylene oxide or butylene oxide and the second alkylene oxide is the other of propylene oxide or butylene oxide.

48. The method of claim 45, wherein the first alkylene oxide is one of ethylene oxide or butylene oxide and the second alkylene oxide is the other of ethylene oxide or butylene oxide.